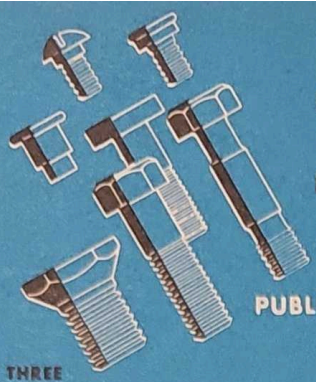
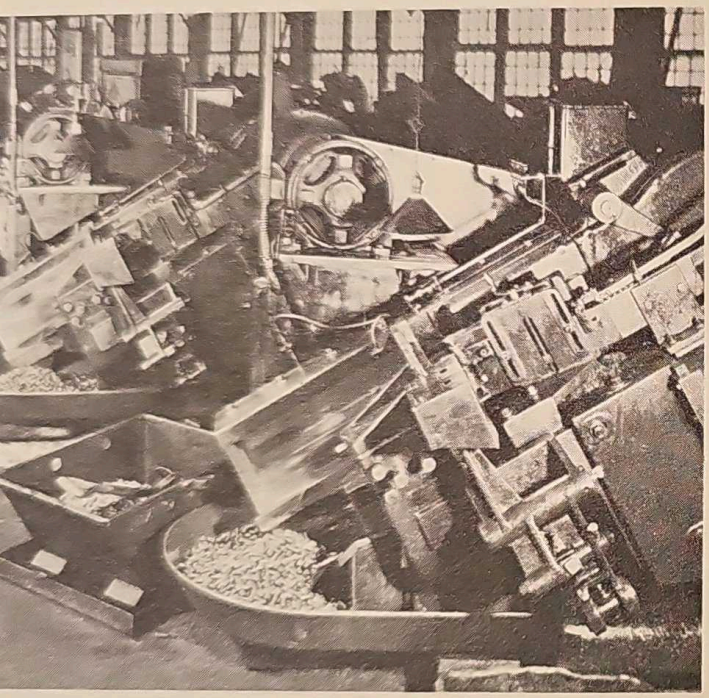


FASTENERS

VITAL IN EVERY INDUSTRY

PUBLISHED BY AMERICAN INSTITUTE OF BOLT • NUT AND RIVET MANUFACTURERS

VOLUME FOUR • NUMBER THREE



From raw material storage to warehouse and shipper . . . the manufacture of industrial fasteners is an excellent example of precision methods applied to mass production.

AMERICAN INSTITUTE OF BOLT, NUT AND RIVET MANUFACTURERS

1550 HANNA BUILDING

HERMAN H. LIND
PRESIDENT
JAMES D. EGGERS
SECRETARY-TREASURER
WM. C. STEWART
TECHNICAL ADVISER

CLEVELAND 15, OHIO

FASTENERS—WHEN, WHERE AND AS YOU WANT THEM—

For more than a century fasteners—bolts, nuts, screws and rivets—have been fabricated on a mass production basis, the method keeping pace with development of improved processes. The large and diversified needs of these small items have developed a pattern of distribution changing with the times and with the need. There is scarcely a home that does not have at least a few on hand. They are important items in every plant, in some cases principally for maintenance, and in other cases for fastening the product together. American bolt manufacturers export them all over the world.

During all these years distribution through wholesalers and jobbers has been a very important factor of the business. A manufacturer's viewpoint of this type of distribution is included in this issue. In a later issue the service a jobber renders will be set forth by a jobber.

Yours truly,

Herman H. Lind

President

Copyright, 1947, American Institute of Bolt, Nut and Rivet Manufacturers

BOLTS TO THE Four Corners

by CHARLES F. NEWPHER
Vice President
National Screw and Manufacturing Company

. . . mass production, with its resultant low costs, would be almost impossible if it were not for the services of the distributor in assembling the myriads of small orders into units large enough for production runs . . .

SINCE the termination of the war, the importance of bolts, nuts, rivets and screws has been borne home to the manufacturing world as never before in the history of the fastener industry. For decades previous to the war the bolt and nut industry had adjusted its production schedules to the point that there was an ample supply throughout distribution channels. Their availability was taken for granted. Due to the general steel shortage, the scarcity of these vital items has continuously interfered with the assembly of many needed articles, and worse yet, the scarcity of common bolts and screws has delayed the reconditioning and repairing of worn-out implements and equipment.

A large but unknown percentage of the fasteners produced is not used for manufacturers' production. Instead, it goes into rehabilitation of every conceivable nature, and repair work in so many fields that its "end use" beggars description. Perhaps 25 to 30 per cent of all fasteners are used in this way. To get the product into these channels, the maker of bolts, nuts, rivets and screws depends on getting distribution through the wholesale hardware jobbers, the mill supply houses, the chain stores, and the mail order houses. The chief function of these marketers is to accumulate the vast aggregate of small volume needs and to translate them into highly desirable orders for bolts, nuts, rivets and screws. Consequently, there is scarcely a distributor worthy of the name who does not order fasteners in full container lots of each item and in carload quantities.

It is fascinating to note how these tiny demands from the corner hardware stores all over the country mount up into tremendous tonnages; and interesting to see how all of the activities of the fastener manufacturer are influenced by this business. As an example in the early days of the fastener business, standardization was sadly lacking, and the product of one manufacturer often would not match with his competitor's standards. This was a source of constant complaint, and the up-to-date manufacturer was always surveying the field to try to get his product acceptable to the world at large.

During the past twenty to thirty years various bodies have worked toward common standards, and today each article is produced to very close dimensional tolerances as set forth by standards that insure interchangeability. Thus, the product of a manufacturer on the Atlantic coast will match up with and work satisfactorily with the product of a maker on the Pacific coast. This standardization was of vital importance during the war when the entire industry

The first step in preparing the completed fastener for shipment is to divide the items which go into each unit package, either by weighing or by counting.

The variety of packaging required is well illustrated by this corner of a fastener manufacturer's shipping room. Here are found kegs, cases, bags, and special packages of all sorts designed to carry the many different items to the four corners of the earth.

poured its product into global warfare, and there could not have been appreciable variance or otherwise the results would have been pitiful.

The products of the industry which move through distributor channels are packaged in neat substantial cartons or wrapped packages, plainly labeled and packed in sturdy containers in established quantities that have been found most desirable to the distributor. Normally, the wholesaler stocks these full cases in his inventory, with supplementary stocks of packaged goods in bins for his smaller orders. In normal times it is not at all unusual for a fair sized wholesaler to stock fifty or sixty carloads of fasteners of various descriptions to cover the full range of sizes and kinds of bolts, nuts, rivets and screws that his customers use.

This calls for unusual production scheduling in the bolt manufacturer's plant. Thousands of different sizes must be on hand to fill the various orders. The same machines make many different sizes, but each size requires a new setup or adjustment of tools. Obviously the run on any given size must be great enough to compensate for the resetting, and the changes on the machine must be infrequent enough to keep the operating time as high as possible. The quantity of each size scheduled for production must also bear some relation to the use of that size as shown by experience. When one considers it is not unusual for a single manufacturing establishment to try to have on hand as many as 50,000 different items, it can be seen that stock and production control, and filing orders is a most detailed and arduous job if economy and efficiency are to be maintained. The jobbing function of bringing together the myriad of small orders of great variety into a large enough overall total for production volume of the various sizes is a big contribution in making mass production possible. Costs and, consequently, prices are kept surprisingly low while rendering great service to large and small users.

Of course, the articles commonly stocked are machine, carriage and lag bolts, together with stove bolts, cap screws, plow bolts, wood screws, sheet metal and machine screws, and all types of nuts. These inventories will vary with the community. For example, a farming community will require an entirely different inventory from one serving an industrial center. The wise distributor builds up his inventories accordingly, and it is only by years of experience that he can establish the proper items to have on hand. The industry as a whole probably produces well over 25,000 separate items of interest to the distributor, and this number is a small proportion of the possible 200,000 items that are regularly listed and available if necessary.

The details of the most popular lines which appeal to the distributor are quite interesting. First and foremost in popularity comes the square head machine bolt with square nut. This is the "all purpose" bolt for mechanical repair the country over. The man on a farm wants a good generous head and nut to give him ample bearing surface—a square head so that any handy wrench will get a good grip. He is not interested in some of the refinements that have occurred in more recent years. He knows that with such a bolt he can fasten together metal parts satisfactorily. For repairing wooden articles and for wood working in general, carriage and lag bolts rank next in popularity. To answer the requirement for smaller fasteners, the distributor carries stove bolts.

By far the most popular nut is the American Standard heavy semi-finished hex which will still be known as a U.S. nut for decades to come. The distributor's customer wants a good, generous, heavy nut and gets it in this particular standard. But for mechanized equipment with fine thread, a reasonable amount of American Standard light hex nuts are used and these are still known as SAE standards. Cap screws are stocked for use in the repair of many items from tractors to washing machines. Plow bolt usage is correctly implied by the name. Generous inventories of wood screws are carried for use in the many fields that employ these little fasteners. They are stocked in steel, in brass to match house and cabinet hardware, and even in nickel plated finish

for the many ornamental uses around the house. The growing popularity of mechanical devices has led to more generous inventories in self tapping sheet metal and machine screws.

Packed assortments have grown more popular as the world has become mechanized, particularly in the farming communities. A generous assortment of odd shapes and sizes many times saves the farmer or ranch owner a long trip to town for a five-cent article needed to keep his machinery running. While assortments are notably weak in supplying any generous amount of a certain size bolt or screw, usually there are one or two fasteners in each assortment that will help out in emergencies.

Chain stores are an important link in this distribution system. They normally confine their sales to the smaller, lighter varieties of products, dealing directly with the ultimate consumer, usually in very small quantities. Mail order houses deal in a very much wider range of products, and during the past several years have even branched over into the mill supply type of distribution. The mill supply houses keep factories operating and normally carry many of the heavier varieties and sizes of fasteners; for the requirements of the normal factory run the full gamut of fastener production. The wholesale hardware jobber, sometimes known as shelf hardware jobber, is perhaps the most important from the fastener manufacturer's viewpoint, since he serves a very much wider field. It is quite usual for such a company to solicit in several states and serve the retail hardware dealers even in the smallest community.

Normally all of these distributors deal with the larger fastener producers, since from them they can obtain the complete range of sizes, kinds and varieties. Naturally this is more economical, since they are dependent upon but one source and there is less bookkeeping entailed in conducting their business. Quite naturally their business is prized by the manufacturer, and in turn a good manufacturing connection has grown to be a very valuable asset, especially in this period of scarcities. Those distributors who had well established sources over the years realized their value, while those who had "shopped around" were quite apt to find it extremely difficult to win an established position in production lines.

Certain distributors pride themselves on having very complete inventories, including even obsolete standards, odd lengths, and kinds of fasteners, so that they can always replace the worn out or broken bolt or screw, no matter how unusual the requirement. This practice leads to large and slow moving inventories, but in certain cases has proven valuable since there is, no doubt, an intrinsic worth in establishing a reputation of always being able to serve.

But the standardization of stock sizes and kinds has been a great help in late years toward reducing costly inventories, and at the same time ensuring ample varieties to furnish a usable fastener for every need. This movement has been supported by every far-sighted distributor.

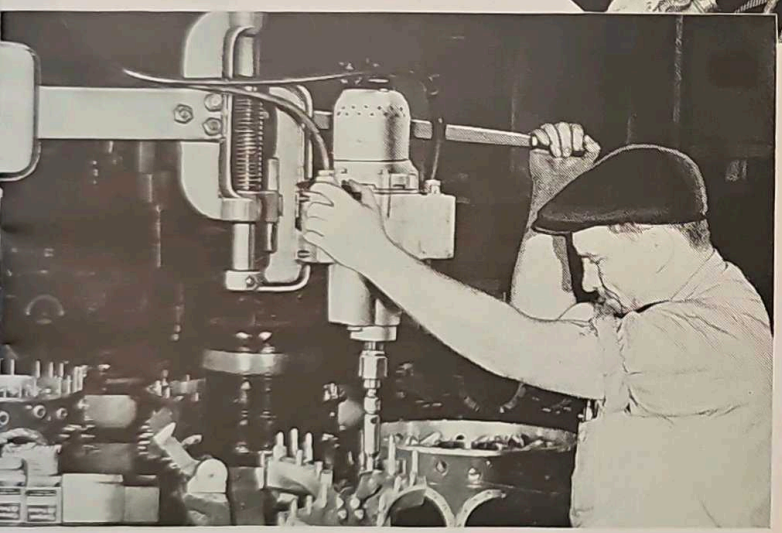
No accurate record is available of the extent of the distributor business, but possibly twenty-five to thirty per cent of all fasteners produced move through these channels. A few highly special lines are handled entirely through distributors on an exclusive basis.

Naturally, there is some conflict between the manufacturer and the distributor when consuming accounts are sold, for the distributor handles many small accounts who depend on him not only for their maintenance requirements, but also for their production needs. Normally the large production requirements flow direct to the fastener manufacturer and usually are of a nature, variety or special specification not stocked by the distributor or the fastener manufacturer, thus necessitating special operations to produce. However, time has adjusted these early difficulties to the point that each recognizes the natural place of the other.

It is easy to see how this class of distributor business is recognized by the fastener manufacturing industry. Policies are shaped and established by the individuals of the producer industry, keeping always in mind this very important type of distribution.

The final step in shipment on the part of the manufacturer is the loading into the freight car. The size of the distributor's order is often such that he can order shipments in economical carload lots.

LOCKNUT ROLL CALL

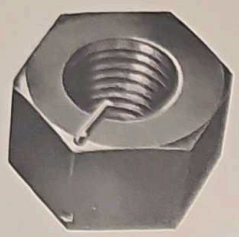


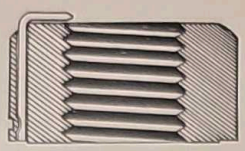
Many weird ideas, some good and some bad, have been devised through the years for locking nuts on bolts, and an untold number of devices have been described in U. S. Patent Office applications. That locknuts are greatly needed and that there is an urgent need for such items, is indicated by the number of people working on the problem. This need has in general arisen because of vibration conditions.

In the past few years many locknuts have been designed on sound engineering principles for their operation, and at the same time with an eye on economy in production and application. Many of these have proven so satisfactory that their use is constantly increasing. Because of the increasing importance of this item, the American Institute of Bolt, Nut, and Rivet Manufacturers have recently established a Locknut Section.

Since many requests for information on locknuts are being received, the publisher of *Fasteners* invited all known manufacturers of locknuts, whether or not they were members of the American Institute of Bolt, Nut, and Rivet Manufacturers, and whose products had reached a commercial status, to prepare a short description for publication in this magazine. The following descriptions have been furnished by the product manufacturer in each case.

ANCO



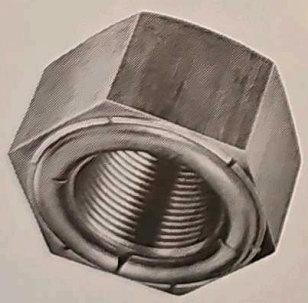


Description: This nut is made in standard threads in any fit desired. The lock is of the wedge type and is an integral part of the nut. It is locked and unlocked with an ordinary wrench, and can be used over and over again on any standard bolt.

Principle of Operation: The end of the locking pin travels between the threads of the bolt and, in so doing, assumes a fixed angle, establishing a point of impingement. This point acts as a ratchet, moving up as the nut becomes tighter, but resisting motion in the opposite direction. A wrench is required to break this locking action in unscrewing the nut.

Manufacturer: Automatic Nut Co., Inc., Lebanon, Pennsylvania

AN-COR-LOX



Description: This is an all-metallic, self-contained, reusable, seating lock type fastener. A soft metal ring is set in the bottom of the nut to form the locking element.

Principle of Operation: When tightened down on the work, the soft metal ring flattens and flows into the threads of the bolt providing an effective lock and seal.

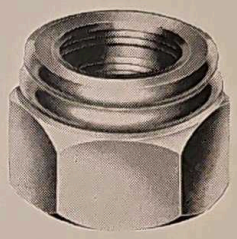
Manufacturer: An-cor-lox Division, Laminated Shim Company, Inc., Glenbrook, Connecticut

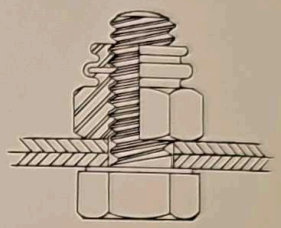
BELLOWS

Description: This is a spring type lock nut, in which the locking and load sections are built into the nut as one unit. The material is aluminum or Duronze, and is manufactured in sizes from No. 8 through ⅜ in. in fine and coarse thread.

Principle of Operation: The bolt threads establish spring tension in the locking section, resulting in a differential thrust in the fastener against the bolt.

Manufacturer: Boots Aircraft Nut Corporation, Stamford, Connecticut





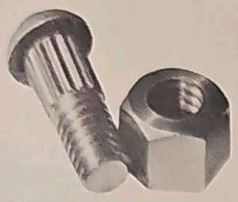
COLUMBIA

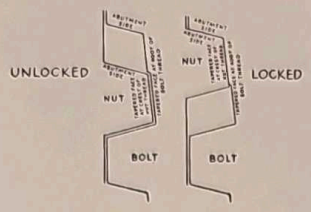
Description: This locking nut, is two piece, of the wedge type, and milled in any size to meet all requirements. It is applied as a regular nut.

Principle of Operation: The top part is slotted and its lower section has a taper which fits into a similar taper in the lower part. As the top part becomes seated, the lower part rides up on the taper, locking the top part to the bolt.

Manufacturers: Columbia Nut and Bolt Co., Brightman Nut and Manufacturing Co.

DARDELET RIVET BOLT





Description: A ribbed bolt with a self-locking nut which is used in place of a rivet. The nut is of the reusable, wedge type design.

Principle of Operation: The tapered crest of the nut thread rests at the point of minimum diameter of the wider tapered and stepped root of the bolt thread in the unlocked position. Positive locking takes place when the nut is tightened against the work, and continued wrenching forces the crest of the nut thread over the root of the bolt thread into the locked position.

Manufacturers:

Bethlehem Steel Co., Bethlehem, Pennsylvania
The Lamson & Sessions Co., Cleveland 2, Ohio

DRAKE

Description: This wedge type fastener is composed of two pieces, a prime nut or lower member which tightens the work to the exact adjustment required, and a locking member which is applied by a firm wrenching action.

Principle of Operation: The faces of the top and bottom members are not drawn together, all contact between them being made on their mating bevels. Each of the members of the lock nut will turn freely on the male threaded mating part until seated or locked in position.

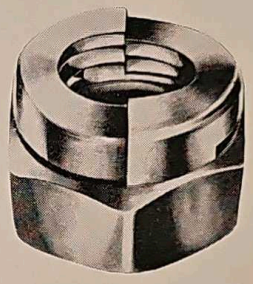
Manufacturer: The National Screw & Manufacturing Co., Cleveland 4, Ohio

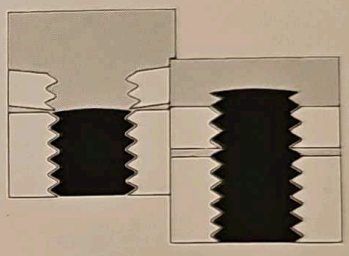
DUALOCK

Description: This is a one piece spring stopnut which provides ample tension for many on and off applications.

Principle of Operation: The blank is sawed so that two wings, each running counter-clockwise, are suspended from a supporting buttress. After tapping the blank, including the wings, the wings are pressed downwards and inwards, thus upsetting the lead of the thread. When a bolt is inserted, the wings are forced upwards and outwards exerting a constant pressure on the thread of the bolt in two directions.

Manufacturer: Dualock Products, Toronto, Ontario



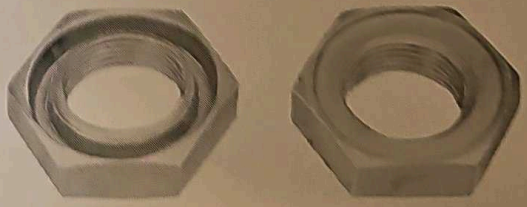


DYNAMIC

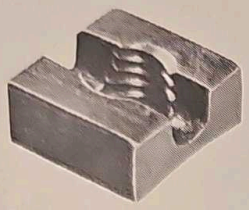
Description: A groove in the top of this nut, and a recess in its base provide a resilient central section which acts as a diaphragm on this seating lock fastener.

Principle of Operation: When the nut is tightened to the adjustment desired, an outward axial spring or flexing action develops. This tension in the upper diaphragm causes a constant pressure of the upper flanks of the threads of the nut and the mating lower flanks of the threads of the bolt, locking them firmly together.

Manufacturer: The National Screw & Manufacturing Co., Cleveland 4, Ohio



"M-F" SPEED HOLDING NUT NO. 2

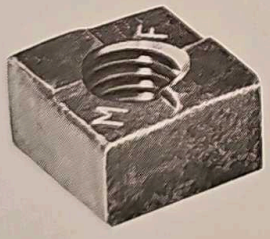


Description: A free spinning, seating lock nut which is used alone. It is lighter in weight than a common nut, and develops the full strength of the bolt. It can be applied to bolts which cannot be held against rotation.

Principle of Operation: When the lower arched surface of the nut contacts the face of the work, it flattens when wrenched, causing the top to pinch in and bind on the bolt threads.

Manufacturers: MacLean-Fogg Lock Nut Co., Chicago 40, Illinois
Steel Company of Canada, Ltd., Montreal, Canada

"M-F" UNITARY NUT NO. 3



Description: A reusable type lock nut in which the top two or three threads are deflected slightly out of the true helix. It starts freely on the bolt, but requires wrenching to final position.

Principle of Operation: The friction induced because of the deflection in the threads clamps the nut in place.

Manufacturers: MacLean-Fogg Lock Nut Co., Chicago 40, Illinois

NYLOK

Description: The Nylok Lock nut is of sturdy lightweight construction and uses a hexagonal molded nylon insert as the locking medium in a steel outer shell formed to accommodate a steel hex nut slug and the hex nylon insert. The use of nylon permits practically unlimited reusability, and it possesses unusual toughness and resistance to chemicals. The moisture absorption of nylon is almost negligible.

Principle of Operation: The diameter of the hole in the nylon insert is somewhat smaller than the diameter of the hole in the nut slug, thus giving a friction grip on the threads of the bolt and holding it fast.

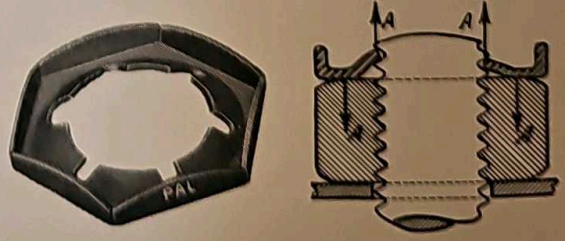
Manufacturer: The Nylok Corporation, 475 Fifth Avenue, New York 17, N. Y.

PALNUT

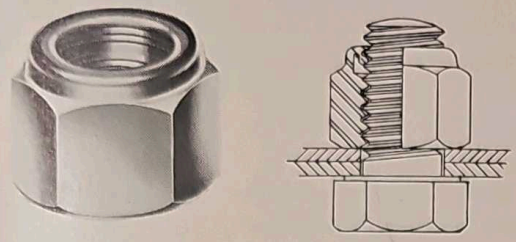
Description: This is a single thread, seating lock, reusable type, lock nut which may be used as a lock nut installed on top of a regular nut, or alone as a self-locking load carrying nut.

Principle of Operation: The locking part of the Palnut is a cone with a hole in the center, whose inner edges are formed to the pitch of the screw thread. This inner edge, which is slotted, forms spring jaws which close and grip the screw thread when the nut is tightened, because of the flattening of the cone center.

Manufacturer: The Palnut Company, Irvington 11, New Jersey



ROLTOP

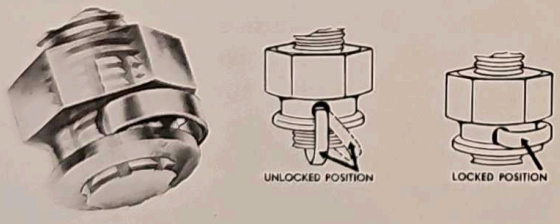


Description: A reusable spring type lock nut in which axial thread play is eliminated giving vibration proof results. The material is steel and production sizes range from No. 10 through ⅜ in.

Principle of Operation: The threads of the bolt establish spring tension in the locking section, resulting in downward thrust by the nut threads of the locking section against the bolt threads, and upward pressure of the nut threads in the load section against the bolt threads.

Manufacturer: Boots Aircraft Nut Corporation, Stamford, Connecticut

SAFETY NUT



Description: This is a dual-purpose, spring type, reusable type, lock nut which is normally used with seven serrations on the bolt thread, thus giving 14 locking positions per revolution of nut. It can be used on any length thread.

Principle of Operation: A snap ring which engages in one of the longitudinal bolt serrations locks the nut in position. When a plain bolt thread is used, it can be used as a stop nut, since the safety ring bites into the thread providing permanent spring tension.

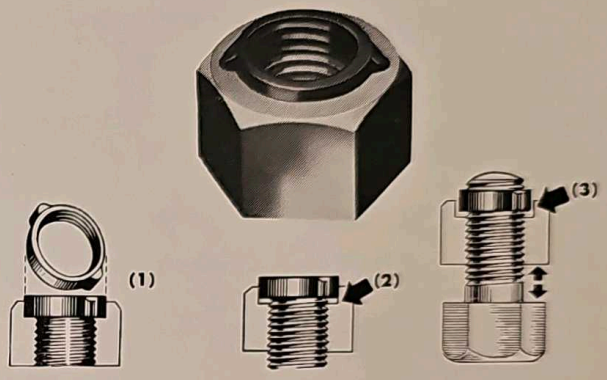
Manufacturer: Simmons Fastener Corp., Albany, New York

SECURITY

Description: This lock nut is a combination of standard nut and oval steel collar with ears (1), fabricated into a unit by press fit of oval collar into counterbore in crown of nut.

Principle of Operation: The threads in collar are misphased so that bolt moves collar away from counterbore (2), isolating it from the nut (3). Since the collar is oval, round bolt locks with collar. The nut is kept from turning by the ears on the collar.

Manufacturer: C. G. Conn, Ltd., Elkhart, Indiana



SELF-RETAINING

Description: This is a one-piece, spring type, lock nut which is wrenched into place causing a positive lock. The nut has a slot cut near the top, which goes partially through the nut.

Principle of Operation: The top part of the nut is compressed slightly when the nut is turned on the bolt. The spring then produces a permanent friction tension against the bolt, and the nut cannot rotate itself.

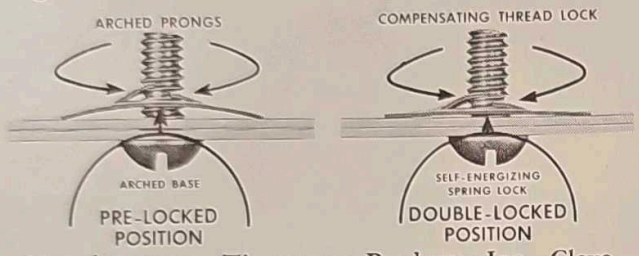
Manufacturers: Columbia Nut and Bolt Co., Brightman Nut and Manufacturing Co.

SPEED NUT*

*Trade Mark Reg. U.S. Pat. Off.

Description: The Speed Nut is a simple seating lock type reusable fastener. It utilizes the inherent qualities of the material of which it is made to provide a double lock, a compensating thread lock and self-energizing spring lock.

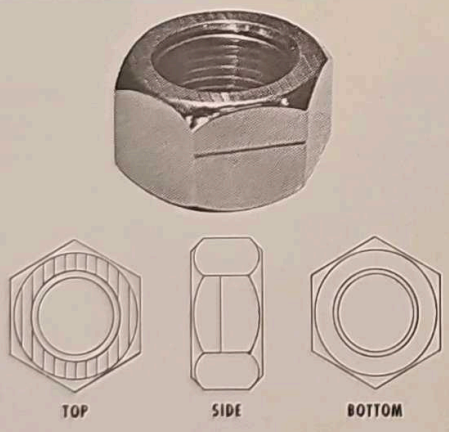
Principle of Operation: As the nut is tightened, the two arched prongs are forced down and inward to engage and lock against the root of the screw thread. In addition, the compression of the arch in both prongs and base give a strong upward thrust against the screw threads.



Manufacturers: Tinnerman Products, Inc., Cleveland 13, Ohio

Shakeproof, Inc., Chicago 39, Illinois

STOVER



Description: A self-locking nut, of the reusable spring type, which has all the conventional weight and strength characteristics of a standard semi-finished nut.

Principle of Operation: The locking feature is obtained by compressing two opposite flats of the nut so that the top becomes elliptical in shape while the bottom remains circular. The elliptical section provides a heavy spring grip on two opposite sides of the bolt, due to the elasticity of the steel in the wall of the nut.

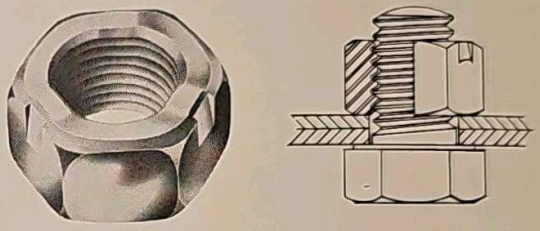
Manufacturer: Stover Lock Nut & Machinery Corp., Easton, Penna.

TRI-LOK

Description: This nut is of the spring type. It is made to American Standard light dimensions, and current sizes being produced are No. 10 through ⅝ in.

Principle of Operation: Locking action is achieved by radial compression at three points by shearing the nut walls. The nut loses its fixed uniformity of section and is capable of radial movement upon assembly with a bolt. A slight downward out-of-phase set is also established in the shearing operation.

Manufacturer: Boots Aircraft Nut Corporation, Stamford, Connecticut

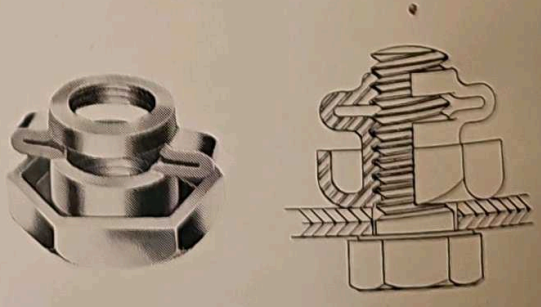


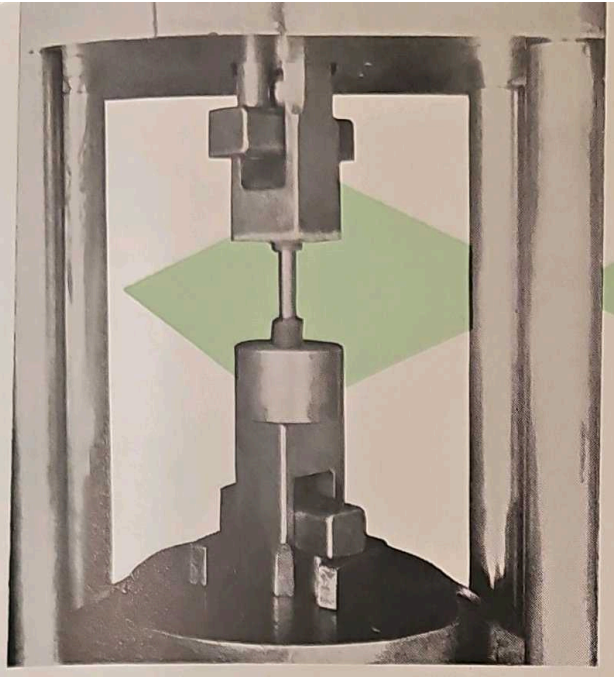
WING NUT

Description: Wing type nuts are made of sheet metal, steel and aluminum, and were designed primarily for weight saving. They are of the spring type and are made in sizes No. 6, 8, 10 and ¼ in.

Principle of Operation: This nut is operated on the same out-of-phase condition of the locking section relative to the load section as the Bellows and Roltop lock nut.

Manufacturer: Boots Aircraft Nut Corporation, Stamford, Connecticut





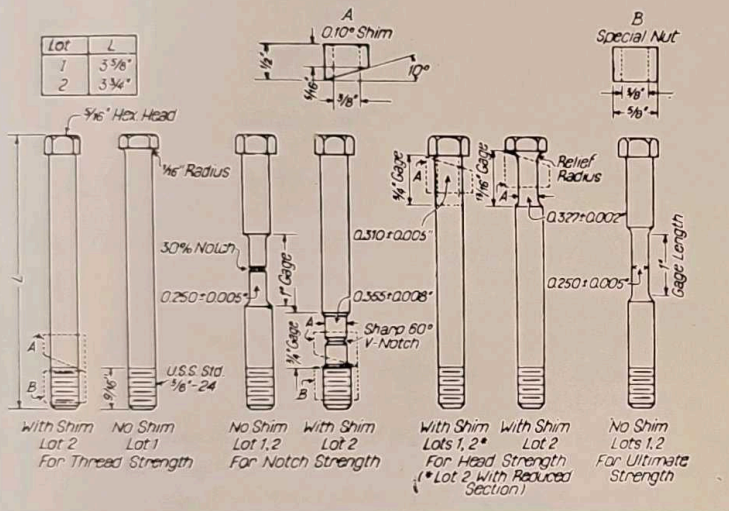


Figure 1—Nickel steel bolts were tested as received and in the sizes and arrangements shown in the sketch.

Figures 2—Sample breaks from testing program. Specimen F was tested with a shim.

DEVELOPING MAXIMUM *Strength* IN ALLOY STEEL BOLTS

by G. Sachs*
Professor of Physical Metallurgy
Case School of Applied Science · Cleveland, Ohio

. . . bolts made of alloy steel will not develop the full strength of the material as indicated by the usual tension test, if bending is present, unless proper fillets are provided under the head of the bolt . . .

RECENT investigations on various alloy steels have shown that sharp notches reduce materially the strength and ductility of cylindrical test bars if the ultimate strength or "strength level" of the steel exceeded a value of approximately 200,000 psi. Tubing subjected to internal pressure exhibited a similar, but not quite as pronounced, "embrittling effect" if the strength level of the steel exceeded a value of approximately 150,000 psi. Cylindrical notched bars and bolts were also found to break at reduced loads, in a brittle fashion, if their strength level was above 150,000 psi and if a bending strain was superimposed upon the applied tension by means of shims placed under the heads of the test bars or under the nuts of the bolts.

It was the particular purpose of this investigation to clarify some of the factors which might cause embrittlement of high strength alloy steel bolts. Bolts, fabricated from S.A.E. 2330 steel, were selected for the investigation. The most important fundamental factors influencing their strength are:

1. Various strength levels, as determined by the tempering procedure after proper hardening.
2. Various shapes of the head, which was found more prone to rupture than the thread, in the range of conditions conducive to brittle breaks, and
3. Various types of loading, i. e., regular tension and tension with superimposed bending.

**Based on an investigation by G. Sachs, P. S. Cole, and R. A. Roth.*

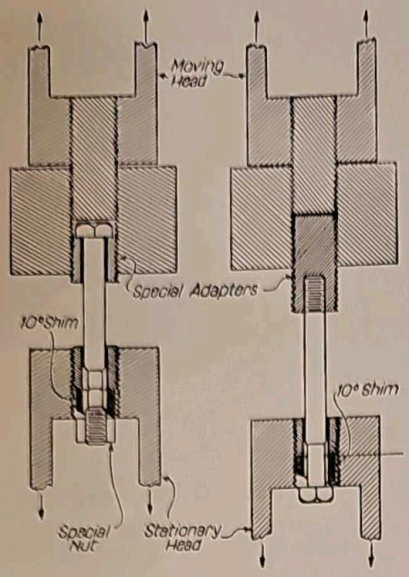


Figure 3—This tensile testing fixture was used for testing the bolts under tension and bending.

Two lots of S.A.E. 2330 bolts, ⅜ inch diameter and 3⅝ and 3¾ inch total length, respectively, (Figure 1), were used for the investigation. They were heat treated by quenching from a vertical furnace containing forming gas into an airlift quenching tank with oil and tempering at various temperatures for an hour in an electric forced air convection type furnace. The hardening temperature, 1500F., was maintained for one-half hour. All specimens were machined before heat-treating; and the results, therefore, apply to a steel with a decarburized surface.

RESULTS

In an early stage of the investigation, it was observed that various failures of the bolts occurred under varying conditions, see Figure 2—Two major types of failure were recognized: breaks through the thread, and breaks under the head. Also minor failures by stripping of the thread and through the cotter-pin hole of the bolts, lot 1, occurred occasionally. Such failures were disregarded in most instances.

Consequently, each test supplied, fundamentally, two values:

a The strength of one of the two sections, the thread root section or the section under the head.

b A stress below the strength of that section which did not fail.

In addition to tests on bolts in the shape as supplied, tests were made also on bolts reduced in section at various points. Some such specimens were provided with a 60-degree sharp notch, which removed 30 per cent of the cross-sectional area of the reduced section. Further series of tests were made on bolts with an increased radius machined under the head. Also, the ultimate strength was determined by testing specimens with a reduced cylindrical section.

Thus, four different strength characteristics of the 2330 steel in various conditions of heat treating were determined:

a. The strength through the thread, or "thread strength".

b. The strength under the head, or "head strength".

c. The strength through the notched section or "notch strength".

d. The ultimate strength or "strength level" of a cylindrical section.

With the exception of the cylindrically machined bars, all other types of test bars were subjected to tensile tests in two ways:

a. By means of regular ball-seat fixtures.

b. With a tapered shim or washer having an angle of 10 degrees.

The tapered shim results in eccentric loading of the test bar, or in a superposition of bending on the applied tension. This eccentricity will be higher in the sections close to the shim than in sections farther away. This enables one to apply a higher eccentricity to the thread (or notch) than to the section under the head and vice versa, Figure 3.

The rolled thread, as well as the corners under the head, and also the machined sharp notch and machined head fillet has a radius of approximately 0.002 to 0.003 inch.

The results of the various series of tests are plotted

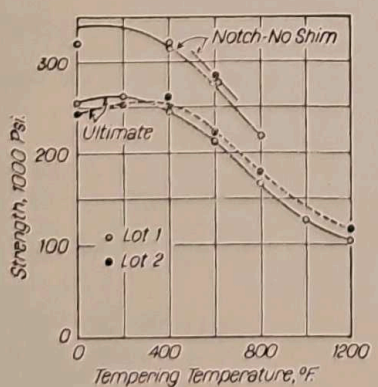
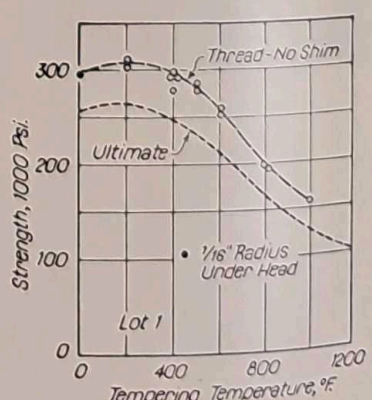


Figure 4—On the left is shown the ultimate and notch strength with no shim.

Figure 5—On the right is shown the thread strength with no shim.



in Figures 4 to 11 against the tempering temperature.

The ultimate strengths of the two lots of bolts, Figure 4, differed slightly, as previously mentioned. A maximum ultimate strength of approximately 260,000 psi was obtained by tempering at 200 to 400 degrees F.

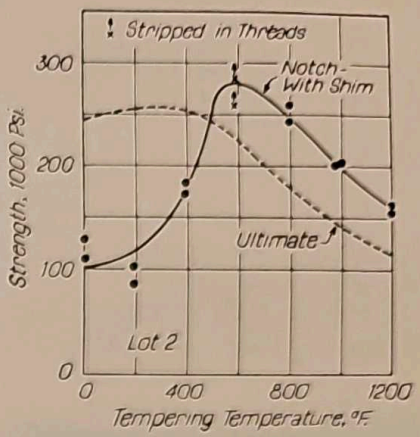
The thread strength, Figure 5, and notched strength, Figure 4, in tests without shim, were almost identical for a given condition. This confirms the previously recognized fact that threads and compound notches behave much the same way as a single notch of the same contour and depth.

Throughout the whole range of the investigated strength levels, both the thread strength and notch strength are 25 — 35 per cent higher than the ultimate strength. The notched section appears slightly stronger than the threaded section, but this may be explained by various factors, such as differences in contour, in decarburization, etc. The absence of low strength values in these tests means that the threaded section of S.A.E. 2330 steel bolts is not susceptible to an embrittlement for any possible heat treatment or strength level, if subjected to regular tension with little or no eccentricity.

However, if a shim is added under the nut, the bolts were found to possess a much lower strength than without a shim. In the series on threaded bolts, very irregular results were obtained and the thread stripped in all tests. This is rather peculiar, as for similar previous tests, results are reported which agree with previous results, and the present tests on notched bars. No attempts were made to reveal the reasons for the stripping of the thread in the present tests.

Thus, a shim under the nut of bolts provided with a notch close to the thread resulted in low notch strength values of the highest strength levels, being less than 40 per cent of the ultimate strength, Figure 6. With increasing strength level, the notch strength increased rapidly, and became practically the same as that of bars tested without shim if the strength level decreased to 225,000 psi or less.

Figure 6—Notch strength with shim.



The section under the head was found to be more susceptible to embrittlement than the thread, Figure 7. In the as-quenched condition, all test bars failed in a cup-like fashion, Figure 2, underneath the head, rather than through the generally weaker section through the thread. Also, if the section was reduced under the head, the as-quenched bars still failed under the head in a brittle fashion, rather than through the cylindrical section. This is interesting in that it proves that the embrittlement of the head is not primarily dependent upon the fiber as determined by the heading process but upon the notch effect of the head contour.

In order to obtain a thread failure for the as-quenched condition, the radius under the head was increased by machining off a part of the head, from a few thousandths of an inch to 1/16 inch. Figure 1. Thus, such a stress relief radius increased considerably the strength of the section under the head, if the conditions are conducive to brittle failures.

The tests with a shim under the head also showed that the section under the head was more liable to embrittlement than the thread, Figure 8. The head strength for the high strength levels, if tested with a shim, was as low as 20 per cent of the ultimate strength. Only when the strength level decreased to 160,000 psi or lower did the head strength become identical for bolts tested with and without the shim, Figure 11, the failure then occurring through the thread or in the reduced section.

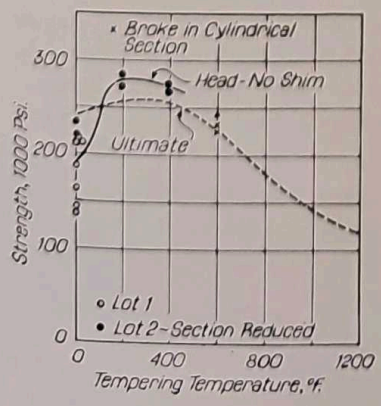
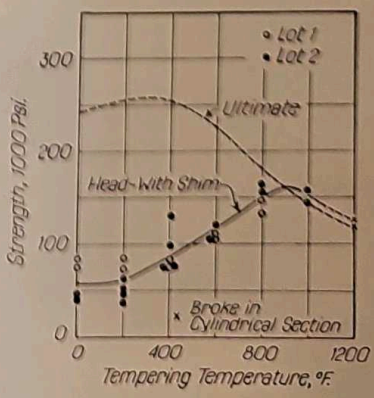


Figure 7 — On left is shown the head strength with no shim.

Figure 8 — On the right is shown head strength with shim.



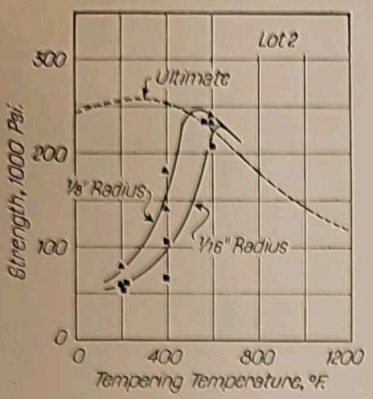
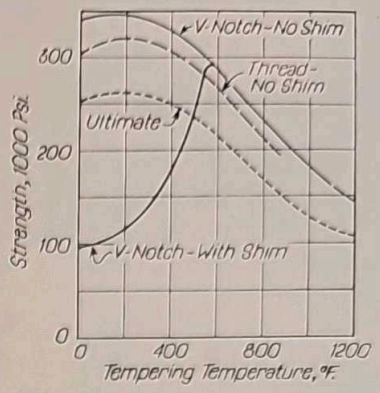


Figure 9—Effect of stress relief radius under head with a shim is shown on the left.

Figure 10—A schematic sketch of the results of various thread and notch tests is shown on the right.



Again, it was found that this embrittlement could be reduced materially by machining stress relief radii under the head, Figure 9. But even a radius of 1/8 inch did not eliminate completely the effect of the shim. However, it raised the range of strength levels which were not susceptible to brittle head breaks to approximately 240,000 psi, Figure 11.

The present investigation indicates a higher tendency towards embrittlement for the section under the head than for the threaded section. However, as clean thread breaks were not obtained in these tests with shims, and as the notch was some distance away from the shim, the actual properties of the threaded section were not revealed by these tests. Previous experimentation on some alloy steels, in which thread and notch breaks occurred close to the shim, yielded low strength values of the strength level was 160,000 psi or higher, while in the present tests low notch strength values were obtained only for strength levels above 220,000 psi. It will therefore be attempted in further tests to clarify this discrepancy and to determine in a more accurate manner the respective sensitivity of the two sections to superimposed bending.

CONCLUSIONS

1. In tension, with little or no superimposed bending, ductile breaks through the threads occur except in the as-quenched bolts.

2. As-quenched bolts show brittle failures under the head at low and widely scattered loads, thus indicating greater notch sensitivity at this point than in the threads.

3. Failures under the head can be prevented by adding a "stress-relief" radius from shank to head. If necessary in practical cases, this may take the form of a semicircular groove having a radius of one-eighth to one-sixth of the shank.

4. Superimposed bending at either the head end or thread end causes brittle failures in these sections at considerably reduced loads. For a 10-degree shim under the head, brittle failures occur at the head for tempering temperatures below 800 F, or strength levels above 160,000 psi.

5. For a shim under the nut, failures occurred at very low loads by stripping of the threads in an apparently brittle manner. Only for tempering temperatures above 1200 F did the thread reach approximately the same strength when tested with a shim as without.

For tempering temperatures less than 400 F strength levels above 250,000 psi, brittle failures were obtained through a 0.002-inch-radius notch placed near the nut and tested with a shim under the nut.

6. Brittle breaks under the heads are suppressed by the use of a relief groove. Commercially feasible radii (1/16 inch) permit superimposed bending without impairment at strength levels up to 225,000 psi.

7. The as-quenched bolt showed a lower tensile strength and a greater tendency toward brittle failures with superimposed bending than a bolt stress relieved by tempering at 200 to 400 degrees F.

8. Bolts of the selected steel and size may be heat treated to 250,000 psi if the straining in service is to be in pure tension, but 175,000 psi is the maximum safe limit if superimposed bending is present.

9. A greater strength level may be used in the presence of superimposed bending if a fillet is used under the head. Possible improvement may result from the use of fillets in the thread bottoms.

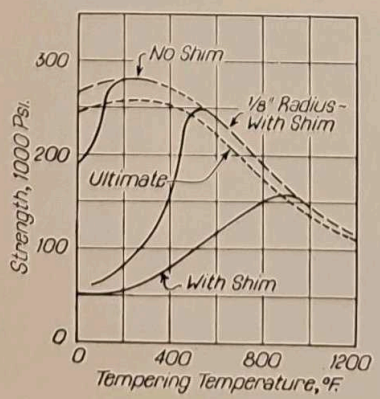
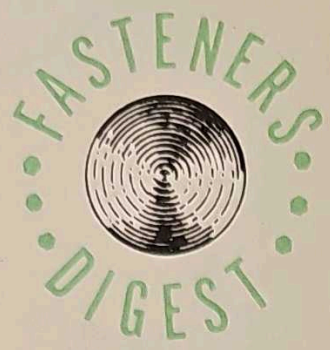


Figure 11—This schematic sketch indicates the results of various head tests.



Screw threads are inclined planes wrapped around cylinders or cones. The inclined plane is the simplest and probably the earliest of all mechanical devices. Although crude screws were made for use in presses in Roman times, the common item was the wedge bolt. These were slotted bolts into which wedges were driven to lock parts together. Rudimentary screw cutting machines were built in France as early as 1569, but not till about 1795 was the slide rest moved by a lead screw. This was one of the world's great inventions. In 1873, the development of the automatic screw machine, and the standardization that took place at that time helped standard bolts, nuts, and screws to become reasonably cheap and plentiful. The discovery of the centerless grinding method of threading all sorts of headless screws can be classed as one of the most interesting postwar achievements in machine shop practice. There is thus nothing static about the technique of threading, and the thread gages of yesterday were not as accurate as the best commercial threads of today.

"Threading—Modern Machine Tools—Part Eight"—Guy Hubbard, Steel, July 28, 1947.

When one is considering the manufacture of a small part, it is wise to first evaluate its applicability to production by automatic screw machine. There are relatively few limitations on screw machine products if their design conforms to a few basic specifications. An important consideration in selecting screw machine products is the wide range of materials in which such parts can be furnished. The most serious charge normally made against producing parts via screw machine is that scrap losses are high due to the fact that the bar stock used must be slightly larger in diameter than the largest cross-section of the part. With some materials this is neither a serious or an expensive factor. The factor of the number of pieces to be made is important. If the quantity is less than 1000 pieces, some other method probably should be considered, and hand screw machines may be satisfactory. If quantities reach 5000 or more, multi-screw machines are indicated. A most important factor is the high speed of production. It is not uncommon to attain hourly rates of 3-4000 pieces.

"Screw Machine Products"—T. C. DuMond, Materials & Methods, August, 1947.

Manufacture of fasteners for use in masonry, concrete and similar applications constitutes an important and highly competitive branch of the metal working industry. Production must be rapid and efficient to insure reasonable profits. Most elements are made by casting, stamping, heading, or wire forming. Casting, particularly die casting, is a very important method, and such production is done at a high rate, and assembly and packing are done on a rapid and efficient basis.

"Casting Fastening Hardware with Dies and Metal Molds"—Herbert Chase, Steel, August 18, 1947.

Blind riveting came into general use in answer to the wartime demand of the aircraft industry for a method of riveting in spots where it is either difficult or impossible to buck a solid rivet. The fact that blind rivets are upset by a pull rather than a blow, and the fact that their shank expansion is controlled led to their use in places not necessarily blind. Soft and pliable materials can now be riveted, where formerly the shank of an ordinary rivet would buckle or tilt, due to lack of support of the shank. Likewise delicate materials that shatter under the violent blows of a pneumatic hammer or riveting gun can be successfully riveted. Some interesting applications of blind riveting have been their use in repairing loose roofing sheets, attaching door hinges to stainless steel refrigeration units, and installing metal insulation retainer sheets in inaccessible locations.

"Practical Applications of Blind Riveting"—Milo Ketchum, The Iron Age, February 27, 1947.

Installing fasteners in masonry and plaster requires special techniques and care. Fasteners in plaster are made with special bolts or screws called toggle bolts which are installed by carefully drilling a hole through the plaster, and then passing the hinged or toggle of the bolt through the hole. When the toggle passes through the wall, it falls or expands across the hole, forming a threaded support into which the screw can be tightened. Fastenings in masonry are made in several ways. One way is to use a plug. Another way is to use an anchor in which a hole is drilled in the masonry the depth of the anchor, and the anchor is designed to expand against the sides of the hole. It is a good idea to use lock washers wherever possible on screws and bolts of fastenings. They will exert a constant tension, thus helping to prevent loosening of the fastening.

"Plaster and Masonry Fastenings"—Thomas Trail, Power Plant Engineering, May, 1947.

USE HEADED AND THREADED FASTENERS FOR ECONOMY RELIABILITY

Litho in U. S. A.